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Review

A Review of Cultural Background and Thermal Perceptions in Urban Environments

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Abstract: Thermal comfort is among the chief indicators of the sustainability of outdoor spaces. However, the complex nature of comfort represents the interaction of several determinants that leads to a perception of the thermal environment. Recently, researchers have paid particular attention to non-physical factors to understand the mechanisms involved in thermal perceptions in urban environments. The extant literature has contended that culture and cultural background are determinants to individuals' thermal perceptions. Therefore, this study aimed to review how the link between outdoor thermal comfort (OTC) and cultural background is investigated. This is, to the best of our knowledge, the first review study on the subject. The study used a systematic literature review approach based on secondary data available in relevant and contemporary literature. The findings first showed the scarcity of research on cultural background and OTC; however, all studies identified corroborated the significant impact of cultural background on thermal perceptions. Notably, the cultural background was found to be the source of variation in thermal perceptions, tolerance to, and preference for certain thermal conditions, thermal comfort requirements and expectations, choice of clothing, and environmental attitudes. The findings provide a sound basis for future researchers to address the research gaps identified. The study also raises policy makers' and designers' awareness of urban environment users' genuine needs and requirements.

Keywords: thermal comfort; culture; perception; thermal experience; multiculturalism

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1. Introduction

Weather conditions are a dominant factor in influencing the perception of comfort in outdoor environments [1,2]. The perception is based on the local communities' thermal experience and expectations. Increased urbanisation has transformed lifestyles, and city dwellers are experiencing meteorological conditions much different from those in rural settings [3]. The increasing number of people living within cities puts the entire socioeconomic-political system at risk of aggravating extreme conditions. Many people living in densely populated spaces, especially in developing nations, puts stress on the existing resources and institutions that are vulnerable to potential risks like fire, earthquakes, or storms and the spread of global pandemics such as COVID-19. As such, improvement in the quality of city life in urban environments can be made through understanding the factors affecting the local meteorological conditions [4]. The concern emanates from an increasing proportion of heat island effects (UHI) with a negative impact on outdoor thermal comfort (OTC). Therefore, an enquiry into OTC has been the centre of researchers' and authorities' attention for many years [5]. A clear understanding of the requirements of OTC is required to create a thermally comfortable urban environments that is well perceived by community members.

This has resulted in a good number of studies on the topic of OTC [6]. As centres of growth, cities can influence decisions and policies on planning and development. City authorities increasingly recognise action on environmental sustainability to adopt and allocate

responsibilities for local resilience and as a platform for new ideas [7], entrepreneurship, and innovation [8].

ASHRAE defines thermal comfort as *'that condition of mind that expresses satisfaction with the thermal environment and is assessed evaluation'* [9]. The provision of comfort and its definition is a contentious and contested issue [10]. Yet, it assumes significance when constructing sustainable buildings, cities, lifestyles, and societies. The urgency with which the current understanding of the issue is being addressed can be traced to the multidisciplinary and multiscale nature of enquiries into it [11,12]. For most purposes, the topic is concentrated on the built structure of urban settings. However, a clear answer to this complex and diverse phenomenon is rather difficult to satisfy in terms of human psychology as it is contextual to the socioeconomic construct of the citizenry. This is because '[. . .] *Issues of lifestyle, fashion, convention, obligation and convenience influence expectations of comfort and the strategies of thermo-regulation considered 'natural' or 'normal'* [13]. Thermal comfort is a complex function because it is influenced not only by meteorological conditions but also by changes in individuals' physiological and psychological characteristics over time. Adaptation to local circumstances is geared to individual thermal perceptions and practices such as the choice of clothing and changing activity patterns [14,15]. In 2003, Nikolopoulou and Steemers [16] argued that meteorological parameters cannot solely account for the assessment of thermal perceptions. Instead, physical, physiological, and psychological aspects of human behaviour are essential to confirm the status of thermal comfort and adaptation.

However, a common formula of comfort for all people is not achievable under the current global discourses. Among various factors, some believe that culture is an integral component of thermal perceptions. Responses to the sensory experience of weather conditions reflect individual adaptations to varying use of technology, clothing, religious rituals, and habits that are all influenced by cultural background [1]. Cultural perspectives help to explain differences in population responses to the same environmental risks. Furthermore, the cultural background has been shown to influence the assessment of human ecology [17] and the social construct of climate-based issues [18]. The importance of the cultural aspect of thermal perception is evident through its inclusion in universal climate change policies and reports issued by international agencies. Table 1 lists several international reports highlighting the key role of cultural background in adapting to a changing climate.

Table 1. A summary of international climate assessment report objectives with relevance to culture.

Report	Objectives	Relevance to Culture
2015 UNFCCC and Paris Agreement [19]	It provides a preliminary assessment of the culture and climate change.	The project was launched at the UNFCCC COP 21 in Paris in December 2015. It was envisioned to engage public opinion and add cultural depth to future climate scenarios.
2014 IPCC [20]	It examines how research reporting on Indigenous peoples' experiences with climate change is framed in IPCC AR5 WGII.	The vulnerabilities facing Indigenous peoples, for example, often differ considerably from those of non-Indigenous peoples inhabiting the same region, as well as between and within Indigenous peoples. These are affected by different factors, necessitating quite different responses, as the human dimensions of climate change are highly place- and culture-specific.
2013 Climate Witness [21]	It compiles individual observations and experiences of change to publicise the effects and advocate for climate change policies.	Structured interviews and posting of videos and photos on this website were used to compile an international database of stories and resources about the meaning and experience of changing weather.

Table 1. *Cont.*

Report	Objectives	Relevance to Culture
2011 National Ecosystem Assessment—United Kingdom [21]	It contains information on the National Assessment of Ecosystems and their contributions to the well-being.	A chapter on assessing cultural services using the economic valuation and deliberative evaluation and applying the Human Scale Development Matrix to link ecosystems and changes to subjective and objective well-being.
2005 Arctic Climate Impact Assessment [21]	It offers a regional scientific assessment of climate change impacts.	Observations of environmental and climate change by Indigenous people were documented using case studies based on existing projects (chapter in the report). Other scientific findings are being subjected to community review.
2005 Millennium Ecosystem Assessment [21]	It presents a global and subregional assessment of changes in ecosystems and links to human well-being.	Assessment of cultural services through review of published science and case studies; focus on knowledge systems, spiritual values, aesthetics, and art. Also, the sense of place informs about the recognised features of an environment.

The broad literature shows much work on cultural adaptation to weather conditions [21], but a clear understanding of cultural response to OTC in a multicultural society is still limited. This review paper attempts to address the various areas where the cultural perception of comfort under a changing climate has been discussed. To date, there has been a paucity of scholarly work examining the significance and role of cultural background in the perception of thermal conditions. Cultural differences in human thermal perception can be best understood when considering the impact of climate change, migration, increased urban densification, increased economic and social mobility, and an ageing society.

Objectives and Structure

This review study, through a systematic literature review of the extant literature, seeks to achieve the following objectives:

1. Understand the role of cultural background in people's thermal perceptions,
2. Explore the impact of cultural background on adaptation to the thermal environment,
3. Identify theoretical foundations of OTC studies concerning cultural background.

The review study is structured as follows. First, the research method used to review relevant OTC studies will be described in Section 2. Next, in Section 3, the profile of selected literature is characterised, followed by an assessment of the relationship between cultural background and OTC, the relevant theoretical foundations of research on the cultural impact on thermal adaptation. Section 4 discusses the need to include individual cultural backgrounds in OTC policies, explores the role of culture and media, and scrutinises the relationship between urban design and culture. In Section 5, the contribution of this paper to the thermal comfort body of knowledge is presented, accompanied by three major recommendations for further research.

2. Method

2.1. Data Collection and Selection Criteria

To achieve the research objectives, this study used a qualitative systematic literature review technique. The study builds on secondary data available in relevant and contemporary OTC literature. As presented below, three criteria were used to select studies relevant to the scope of the study: an inquiry into the connection between cultural background and thermal perceptions.

i. A focus on thermal comfort conditions in urban environments,

ii. Human participants' involvement concurrent with the measurement of biometeorological conditions,
iii. A cross-cultural representation in diverse geographical settings.

This study used three academic search engines (Google Scholar, Web of Science and Scopus) to obtain relevant research outputs. The search terms used included "thermal comfort", "microclimate", "thermal perceptions", "thermal preference", "cultural background", "thermal experience", "adaptive capacity", "outdoor spaces" and "urban comfort".

2.2. Data Screening and Analysis

The study employed a PRISMA (Preferred Reporting Items Systematic Reviews and Meta-Analyses) diagram [22] to guide data collection and screening. As depicted in Figure 1, the diagram involves four major steps. In the first step (identification), 93 relevant articles dating from 2009 to 2021 were gathered; included in these publications were those identified in search engines and additional sources found in the reference lists of these publications. Next (screening), duplicates (e.g., multiple publications of one study) were removed and the number of publications was reduced to 80 articles. In the same step, the abstracts of these articles were analysed, which resulted in 33 articles. Next (eligibility), the evaluation criteria mentioned in Section 2.1 were applied to these articles and the final number at this step became 25. In the final step (included), after reviewing the full texts, only 14 publications were relevant, matching the selection criteria and usable for this review article (Figure 1).

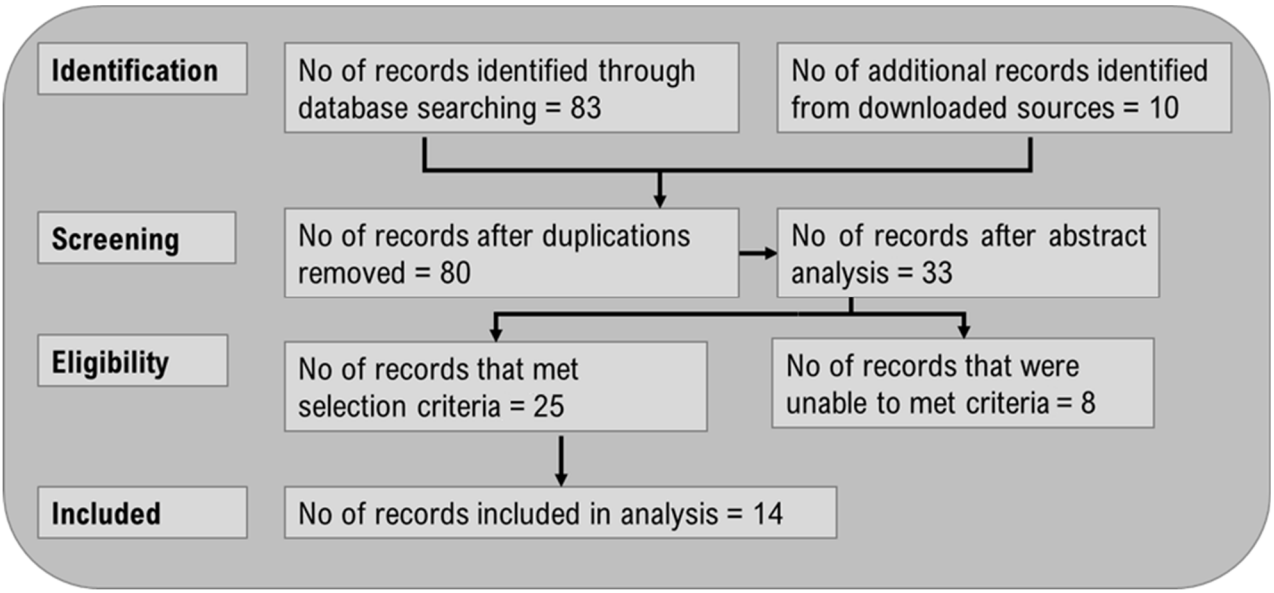

Figure 1. A flow diagram of PRISMA [22].

In the first step of the analysis, the Köppen–Geiger climate classification system was employed to determine the climatic context of the studies reviewed. As Chen and Chen [23] suggested, the adoption of a climatic approach helps organise the study in the context of the local microclimatic characteristics increasingly used by the scientific community. This empirical system aids in determining the climate type for any region over 30 years, as defined by the World Meteorological Organization (WMO).

3. Results

The review resulted in several studies that investigated people's thermal perception in the context of cultural experience, preference, and perceptions. The relationship between cultural background, thermal perception, comfort, and expectation along with some responses to local microclimate were the prime focus. The following sections provide an

analysis of the profile of studies reviewed, the cultural aspect of thermal comfort and the application of theoretical foundations to explain comfort data, and the impact of cultural background on thermal adaptation.

3.1. Profile of Reviewed Studies

The review results showed that 14 field studies captured the impact of cultural background on outdoor thermal perceptions. The comfort data were collected between 2005 and 2020 and involved field assessments in five continents and 12 countries (Figure 2).

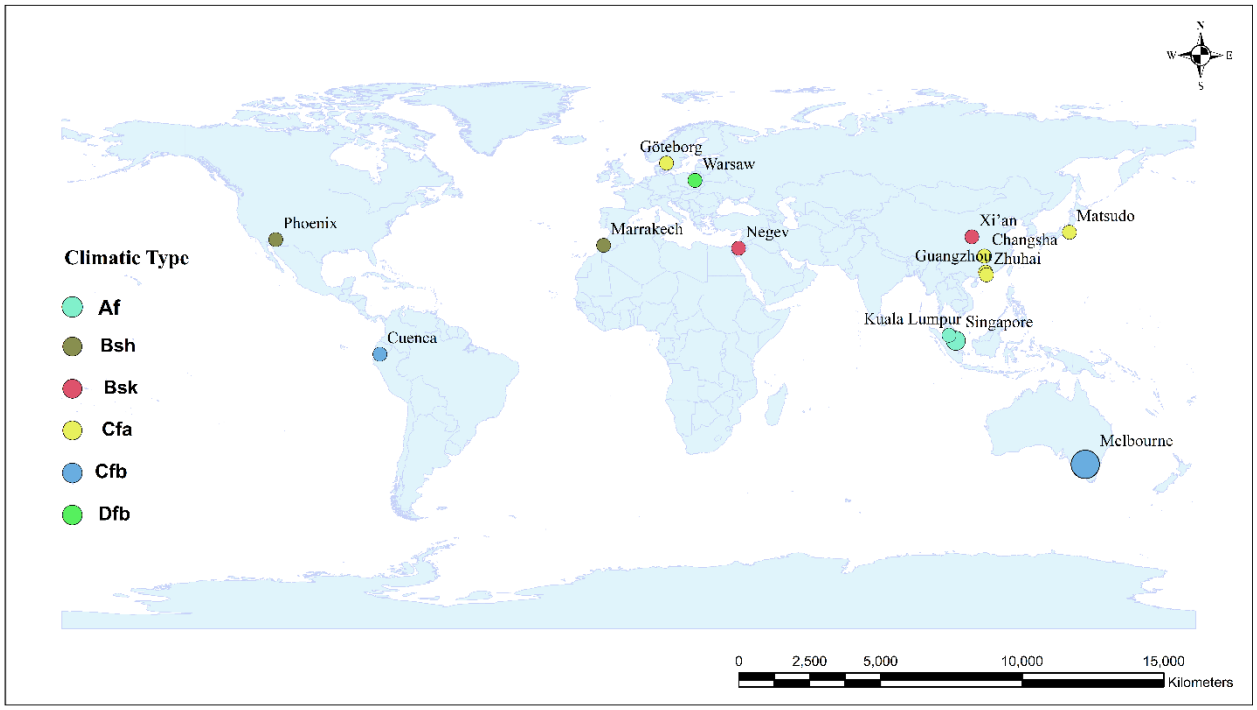

Figure 2. Geographical distribution of cities where selected studies were conducted. Source: Authors.

As presented in Table 2, all studies reviewed used concurrent field measurements with a questionnaire survey to collect comfort data. In one study [24] a remote survey was conducted that was preceded by in-depth interviews to understand the cultural background of participants. In three studies [25–27] observation was also used for understanding participants' outdoor usage behaviour, of which only one study investigated the link between cultural background and outdoor usage behaviour [27]. In two cases [26,28], the results of one study were disseminated in more than one journal article. However, they were only analysed once in this study. As such, all studies involved human participants, with various sample sizes ranging from 106 [25] to 7597 [29]. About 57% of studies reviewed (n = 8) employed PET (PET: physiological equivalent temperature, UTCI: Universal thermal climate index, AT: Apparent temperature, PMV: Predicted mean vote, Ta: Air temperature) as the OTC index, which was followed by UTCI (21.4%, n = 3).These two indices are specifically designed for outdoor settings. Furthermore, most studies used the Likert scale of thermal sensation votes (TSVs) to collect participants' perceptions of the outdoor thermal environment.

Table 2. Summary of recent OTC studies from a cultural point of view.

References	Location, Climate, and Methodology	OTC Index Used	Summary of Findings
Kenawy and Elkadi [25]	Urban public places in the city of Melbourne, Australia, temperate ocean climate (Cfb). FM, Q, O	PET	The study endorsed the impact of climatic backgrounds on outdoor users' TSVs, with a strong relationship between cultural diversity and thermal comfort. The difference between cultural and climatic backgrounds showed significant results for variation in TSVs. It concluded that cultural influence dominates the perception of thermal comfort.
Lam et al. [29]	Three university campuses in Guangzhou, Zhuhai (China) and two gardens in Melbourne (Australia) with a humid subtropical climate (Cfa) and oceanic temperate climate (Cfb). FM and Q	UTCI	The findings suggested that people's thermal sensations are influenced by a complex interaction of stress levels regarding thermal comfort index, climate zones, and prior environmental exposure.
He et al. [32]	Five open campus spaces in Xi'an (China) semi-arid (BSk) and humid subtropical (Cwa) climate zones. FM and Q	UTCI	The results showed that Pakistani students were more tolerant and better adapted to uncomfortable temperatures than the Chinese because of differences in clothing and dietary habits. The preferred temperature (T_{pref}) for the two groups varied as a result of their thermal experiences. The Chinese desired warmer temperatures because of their long exposure to cold conditions; in contrast, the Pakistanis desired cold conditions as they came from hot and dry regions.
Heng and Chow [30]	A large urban park in Singapore (Singapore) with a tropical rainforest climate (Af). FM and Q	PET	Respondents residing for more than six months in Singapore achieved thermal neutrality, suggesting that a greater degree of thermal adaptation likely developed during acclimatisation to local climate through a combination of physiological, behavioural, and psychological circumstances.
Linder-Cendrowska and Błażejczyk [37]	A marketplace in Central Warsaw (Poland) with humid continental (Dfb). FM and Q	PET	The study confirmed that respondents' places of origin and climate has a significant influence on creating thermal sensations and preferences.
Lam et al. [31]	Two botanical gardens in Melbourne (Australia) with an oceanic temperate climate (Cfb). FM and Q	AT and UTCI	The results confirmed that visitors' thermal preferences are influenced by their country of origin because of the differences between the expectations of local and overseas visitors. Clothing as a major factor in visitors' thermal sensations in the garden reflects cultural and ethnic differences. Because they travelled from diverse climatic zones, the tourists demonstrated different expectations and preferences for comfort compared to the local Australians.
Galino and Harimida [33]	Two university campus sites along the Tomebamba riverbanks, Cuenca (Ecuador), with Cfb. FM and Q	PET	The results proved a significant but low impact of cultural background on participants' TSVs.
Brychkov et al. [24]	An educational campus in Negev (Israel) with a semiarid climate (BSh). II, FM and Q	T_a	The study concluded that different climate–cultural backgrounds may play a role in differences in thermal perception.
Shooshtarian and Ridley [26,34] Shooshtarian and Rajagopalan [35]	An educational campus in Melbourne (Australia), with oceanic temperate climate (Cfb), Q, O, FM	PET	The analytical results revealed that cultural background can moderate perceptions of weather conditions in study areas.

Table 2. *Cont.*

References	Location, Climate, and Methodology	OTC Index Used	Summary of Findings
Yang et al. [36]	University campuses, urban parks, and various public spaces in Singapore (Singapore) and Changsha (China) with tropical rainforest (Af) and a humid subtropical climate (Cfa), respectively. FM and Q	PET	The study suggested that people in Singapore and Changsha have different OTC requirements because of the outdoor weather variations in summer in these two cities.
Makaremi et al. [38]	Educational campus in Kuala Lumpur (Malaysia) with hot humid equatorial climate type (Af), FM and Q	PET	The comparative study showed thermal conditions to be more tolerated by local students than international students. Along with the influence of climatic conditions, psychological adaptation induces the sensation of tolerance in the international students because of their outdoor environmental expectations in a tropical warm and humid climate.
Aljawabra and Nikolopoulou [27]	Urban public spaces in Phoenix (USA) and Marrakech (Morocco) with a hot-arid climate (Bsh). Q, O, FM	PMV	The findings showed that cultural differences tend to influence thermal comfort and usage of outdoor spaces. Those with higher socioeconomic/educational status were more sensitive to the current outdoor climate conditions.
Knez and Thorsson [28,39]	Urban parks of Göteborg (Sweden) and Matsudo (Japan), with maritime (west coast) climate (Cfa) and temperate climate (Cfa), respectively. FM and Q	PET	The results suggested that people from different cultural backgrounds with different environmental attitudes psychologically evaluate an urban space differently, despite similar thermal conditions.

FM: field measurement, Q: questionnaire survey, O: observation, and II: in-depth interview; T_{pref} is the air temperature at which at least 50% of people require no change in current thermal conditions.

The selected studies were conducted in six Köppen–Geiger climate classes: Af (tropical rainforest climate), BSh (hot semi-arid (steppe) climate), BSk (cold semi-arid (steppe) climate), Cfa (humid subtropical climate), Cfb (oceanic climate), and Dfb (warm summer continental or hemiboreal climates). This range of climate conditions represents adequate cultural diversity to review the climato-cultural aspect of thermal comfort studies. The data collection in these studies was performed in outdoor spaces across urban parks and gardens [27,28,30,31], university campuses [24,26,29,32–36], a marketplace [37], and various other public spaces [25,38].

3.2. The Trace of Cultural Background in Thermal Perceptions

The results of the review showed that people's thermal perceptions were affected by the prevalent cultural context. Several studies suggested that affiliation with different climato-cultural groups corresponds to variations in outdoor thermal perceptions. A statistically significant relationship was found between cultural diversity and thermal perceptions in Australia [25,29,31,34], China [29,32], Singapore [30], Poland [37], Ecuador [33], Sweden and Japan [27,28], Malaysia [36], Marrakech and Phoenix [38], and Israel [24].

As presented in Table 2, the differences in thermal perceptions across culturally diverse outdoor space users was noted by Kenawy and Elkadi [25] in Australia. Similarly, Lam et al. [31] found that Chinese tourists' thermal perceptions and preferences differed from those of Australian residents. Shooshtarian and Ridley [26] noted that cultural background statistically contributes to people's thermal perceptions. Knez and Thorsson [27,28] considered different geographical/climatic zones as different cultural backgrounds. They saw cultural background as what has been inherited rather than what the world presents. Cultural background was inextricably linked to social norms, level of knowledge, and

access to technology, religion, and traditional beliefs. [26]. Cultural background may also influence people's clothing-related behaviour. In addition to the physical dimension, social and cultural influences strongly influence clothing habits [13]. The connections between clothing habits and fashion, thermal regulation strategies and socio-cultural expectations are rarely explored [13]. This phenomenon occurs in some countries where local cultural values are dominant, and people's clothing habits do not change in response to thermal conditions. This is prevalent in the hot-arid region of Marrakech and may limit the options for thermal adaptation that significantly impact thermal sensation [38]. Knez and Thorsson [27] indicated that people who prefer open air can better tolerate the thermal environment. This argument was supported by the claim that cultural and social factors affect behaviour, beliefs, and perceptions that represent pockets of information they termed *schemata*. Aljawabra and Nikolopoulou [38] found that those who consider themselves to be outdoor people are better adapted to thermal conditions and can stay out in the open for longer periods.

In analysing the influence of socioeconomic level, Shooshtarian and Ridley [26] and Galindo and Hermida [33] found that thermal comfort levels differed significantly across cultural backgrounds. Studies [30,32] have shown how inhabitants from diverse backgrounds may have experienced more than one climate. Differences in thermal sensation among participants from wide-ranging cultural backgrounds may be caused primarily by physiological and psychological adaptation [36]. Knez and Thorsson [27,28] indicated that national characteristics can inspire people's choices. The Japanese, for example, may value outdoor spaces less strongly than Swedes. Subjects' current thermal perceptions are driven by their previous thermal experiences and expectation [4]. In conceptualising long-term and short-term thermal history, research has suggested that exposure to a particular climatic condition for a long period helps subjects to adapt to that condition. Comparative research studies have shown that residents make up a higher percentage of neutral thermal sensation votes than foreign visitors. Lindner-Cendrowska and Błażejczyk [37] divided interviewees into three groups—local, domestic, and foreign—and found that local respondents had the highest percentage of neutral TSVs, followed by domestic and foreign respondents. They revealed that tourists preferred the warmer conditions in the city square and attributed it to allesthesia.

Makaremi et al. [36] drew similar conclusions in hot, humid Malaysia. The outdoor thermal environment was acceptable to the local students; on the other hand, it caused discomfort to the international students. Yang et al. [35] compared the OTC between Singapore and Changsha and found that residents of Changsha were more tolerant of the thermal conditions, which was statistically significant. Singapore residents regarded the thermal environment as warmer than did Changsha residents. Singapore respondents were also more sensitive to temperature variations than Changsha respondents because Singapore respondents experienced a narrower temperature range than the latter. People who have adapted to a wide range of room temperatures may be less sensitive to change than those who are used to smaller changes. He et al. [32] found Pakistani students to be more tolerant and better adapted to uncomfortable temperatures than Chinese students because of their different dietary habits and clothing. The Pakistani students preferred the cold conditions prevailing in Xian more than the Chinese residents. This reflected their clothing and dietary habits, as well as expectation and adaptation.

3.3. Theoretical Foundations of Assessment of Cultural Background in Thermal Perception

Cultural background influences residents' behaviour and subjective evaluation in outdoor spaces through cultural norms and national characteristics. Theoretically, culture has been defined as a set of rules that people as a group, society, or nation follow. Traditional comfort data processing methods are frequently blamed for their inability to explain thermal satisfaction achievement. Emerging theories appear to offer a solution to this growing problem. An attempt has been made here to investigate the use of theoretical

frameworks to interpret comfort data in the selected studies. The findings revealed that thetheories in outdoor thermal comfort research are extremely limited [24,29,33,34,37].

Theoretically, thermal comfort research is built on (i) the heat balance models based on the laboratory studies of Fanger [40] and (ii) the adaptive models based on the field studies of de Dear and Brager [41]. Both have been developed for indoor thermal comfort, yet the models do not properly estimate people's thermal satisfaction. Shooshtarian [42] attempted a comparative analysis of theories related to OTC and their application in model building, to comprehend the mechanism involved in the attainment of OTC.

Studies were categorised according to the theories used, which made comparison possible. Since the theories differed from one subject field to the next, it was easier to classify them based on similarities than differences. The selection criteria derived inspiration from the social cognitive theory, which helps us understand interactions with the built environment and related perceptual and behavioural responses. This resulted in a very small number of sources, which supported the contention that theories are used in a limited way in outdoor thermal comfort studies. In one study, Shooshtarian and Ridley [26] attempted to connect cultural background with human attitude and behaviour with the Socio-Ecological System Model (SESM). The factors that influence thermal perceptions are classified into five environments: (i) individual, (ii) social, (iii) physical, (iv) psychological, and (v) policies and standards. Thus, the model encompasses all the features required to consider HTC, cultural background, and urban policy and design.

Shooshtarian and Rajagopalan [34], in their study conducted in Melbourne, Australia in 2017, adopted a warmth scale to measure the thermal satisfaction of the subjects under study during different seasons. This was made possible by taking into consideration the neutral temperature (T_n, the neutral air temperature at which most people feel neither cold nor warm), T_{pref}, and acceptable thermal range (ATR, acceptable thermal conditions acceptable to a large number of people (80% according to ASHRAE [9]) in typical conditions). Allesthesia as a concept has been used to show the difference between T_{pref} and T_n (PET) values in various seasons. According to the authors, people preferred higher T_{pref}/T_n values (positive allesthesia) for two reasons: firstly, they had endured a prolonged period of cold thermal conditions during the preceding six months (i.e., autumn and winter), and secondly, they were still subjected to inclement weather in spring. Shooshtarian and Ridley [26,34] investigated the connections among the various contextual factors affecting people's TSVs using this model in Melbourne, Australia. The authors changed the structure of this model to group contextual factors into five layers (environments): (i) individual (e.g., gender, age, level of clothing insulation, and activity, etc.); (ii) social (e.g., companionship, cultural background, and position); (iii) physical (e.g., weather conditions, spatial features, type of user, etc.); (iv) psychological (e.g., frequency of usage, seasonal change, thermal history, etc.); and (v) policies and standards. This study found that these layers could alter people's thermal perceptions to varying degrees. Individual and social factor results were presented in [26], physical and psychological factors were mentioned in [34], and policies and standards were noted in [35]. This is a comprehensive model that can be applied to other thermal comfort studies.

Brychkov, Garb and Pearlmutter [24] mapped the impact of climato-cultural diversity on thermal perception and adopted the adaptive thermal comfort model to show the effect. A comparison of thermal perception and comfort between two distinct groups of native and non-native students was based on (i) the significance of short-term acclimation (resulting from changes in the immediate thermal environment), (ii) long-term acclimation deriving from an individual's thermal history, and (iii) thermal expectations. The campus study served as a climato-cultural laboratory for the researchers of multinational groups for systematic comparison in the same climatic setting. They established experimental evidence that thermal perception varies with differences in inter-group thermal perception that are quantifiable.

Lam et al. [29] used a model of the interaction of people's long- and short-term thermal histories to understand outdoor thermal comfort. Acclimatisation and thermal

history can determine the mean thermal sensations of residents from distinct climatic zones within a similar UTCI range. The cities under investigation were in subtropical (Guangzhou, Zhuhai) and temperate climate zones (Melbourne). The outdoor thermal comfort requirements varied among Guangzhou, Zhuhai, and Melbourne residents, as evidenced by the differences in MTSVs (mean TSVs) within a similar UTCI range and preferred UTCI. When surveyed in cities located in various climate zones, respondents from a similar climatic background reported different MTSVs within a similar UTCI range.

In similar climatic zones, the respondents of Guangzhou and Zhuhai displayed different thermal sensations. The UTCI range was narrower for Guangzhou and Zhuhai than for Melbourne. This is attributed to the range effect, where Melbourne had a wider range of MTSVs because of a wider range of air temperatures in the Australian summer during the 1981–2010 period. Thermal adaptation to the local climate was common among people from similar climatic backgrounds, resulting in differences in thermal perception. The authors also considered allesthesia to have influenced the pattern of thermal sensation. This was indicated through the degree of exposure to the environment or solar radiation and the performance of an activity (standing or walking). Melbourne's difference in thermal sensation under heat stress conditions was related to thermoregulation and body heat exchanges.

In 2018, Galindo and Hermida [33] used a modified version of the model (socioecological system model: SEM) for Cuenca, Ecuador, to investigate the effect of three clusters of contextual factors on people's TSVs. These clusters included: corporeal (e.g., gender, age, and skin tone, etc.), mental (e.g., perceived urban agreeability, insecurity, and noise) and social (e.g., company, occupation, and cultural background). The findings demonstrated the cumulative effect of each environment on people's TSVs. However, the model used in this study failed to account for urban design (e.g., aspect ratio and sky view factor) as well as psychological factors (e.g., expectation, experience). The inclusion of these variables could have provided a more accurate picture of people's thermal experiences. Overall, both studies explained the differences in the thermal requirements of a group of individuals by using EST and its associated models (i.e., SESM and SEM).

In Warsaw, Poland, another study [37] compared people's TSVs under comparable biometeorological conditions in two transitional seasons, spring, and autumn, to confirm the existence of perceptual allesthesia. The results showed thatthe respondents in spring generally rated local thermal conditions warmer than autumn, despite the similar biometeorological conditions between these two seasons. The results revealed a normal pattern of TSVs, ruling out the use of allesthesia in this study.

3.4. The Impact of Cultural Factors on Thermal Adaptation

Studies on thermal adaptation in hot and humid regions have looked at how psychological factors influence thermal comfort, revealing that, because of acclimatisation, people who live in these areas have a higher tolerance for high temperatures than people who live elsewhere [30]. Comparing the thermal sensations of people inhabiting the same climatic zone indicated different comfort ranges [27,28]. Because of the air conditioning in Phoenix, when compared to Marrakech, people were more receptive to changes in air temperature and solar radiation, indicating a narrower comfort zone. Strikingly, in both cities, people from lower socioeconomic backgrounds were more comfortable at a wider range of temperatures. This is a notable finding given the monetary and environmental costs of using air conditioning.

4. Discussion

4.1. Policy and Culturally Dependent Thermal Comfort in Outdoor Spaces

Comfort as a socio-cultural achievement is temporary and uncertain. The study results showed that the effect of cultural background on thermal perception is more significant relative to climate background. Thermal comfort and satisfaction do not necessarily represent the thermal environment but are the outcome of the personal values and perceptions

people bring with them to an area. As both culture and climate are changing, a cross-cultural analysis is the best means to identify how people perceive weather conditions. In some instances, they contradict local knowledge and practice as government decisions dominated by urban elites are imposed on the rural poor, raising doubt about government policies. When defining the problem, the debate surrounding climate, cultural background, and comfort is dominated by the physical sciences with little hope for a commercially viable solution in a political scenario. Little attention has been given to the behavioural aspects of cultural background that explain why people accept or reject scientific evidence, analysis, and conclusions. Academic scientists have a duty to bridge this gap and effectively communicate with society. This is possible only when policies are drafted in conjunction with on-the-ground reality, engaging with residents to create living conditions that are more conducive to their well-being.

The challenge lies in interpreting the perception of thermal satisfaction and acceptability, both of which are non-quantifiable entities. In this context, models were developed to scale up the comfort level. The integration of the cultural aspect of people and outdoor thermal comfort has helped to a certain degree to provide results that can be mapped to illustrate the diversity in comfort perceptions. Socio-cultural and environmental stress is a driver for enhanced outdoor urban design and, therefore, comfort.

It is often argued that no uniform temperature value can be universally applied because the perception of comfort and satisfaction is contextually based. A cross-cultural comparative study between the Swedes and Japanese [28,39], sharing the same climatic zone, revealed different attitudes towards thermal preferences. The Swedes found the warm environment more pleasant than the Japanese, which affected their perceptual and emotional estimations of outdoor urban places. The difference in thermal assessment amongst the members of the two cultures derived from the long-term memory, schemata that may define the human–place relationship. Knez and Thorsson [39] indicated that people with pro-environmental attitudes are better able to tolerate the thermal environment.

More than one study [33,37,38] has used allesthesia as a sensation of pleasantness or unpleasantness to emphasise people's perceptions of comfort in outdoor places. The phenomenon of perceptual allesthesia was confirmed by another study [33] in Warsaw, Poland. Lindner-Cendrowska and Błażejczyk [33] compared people's seasonal TSVs under similar biometeorological conditions in spring and autumn and found them to differ. The respondents found spring to be warmer compared to autumn conditions, despite having similar weather conditions in both transitional seasons. The authors attributed this situation to perceptual allesthesia. It is a condition that can contextualise the personal psychology of individual respondents to add to their thermal judgments about comfort.

Aljawabra and Nikolopoulou's [27] interpreted thermal satisfaction as perceived through a target population's cultural characteristics and socioeconomic attainment. Culture is a dominant factor in generating a social norm where clothing habits are not modified in response to a thermal condition, highlighting society's influence on the usage of outdoor spaces or the environment. Galino and Harimin [33] highlighted how foreigners react to a place. A perception of fear and insecurity among foreign nationals causes discomfort arising from fear and noise, a non-thermal element.

Acclimatisation as an influencer for determining the significance of cross-cultural differences in thermal perception and tolerance has proved useful in determining thermal perceptions and adaptive behaviours of users of outdoor open spaces [30,32,35,36]. The defining factor for such differences may be related to the respondents' expectations and experiences and the design of outdoor places. The authors recommended careful urban and landscape design that considers the users' thermal expectations, thermal history, and individual characteristics (cultural background, clothing, preferred activities, and thermal adaptation behaviours). Following the argument of Nikolopoulou and Steemers [16], the control over microclimates is limited in outdoor spaces and, therefore, freedom of movement is critical to the users of open spaces. This can be satisfied, for example, by a pergola [38] or the planting of more shady trees in gardens [30]. Yang et al. [36] saw

thermal adaptation to the local climate as a way to develop thermal comfort. Lam et al. [31] found the cultural differences in thermal perception dominant among Melbourne tourists, whereby their country of origin influenced their thermal preferences. Chinese tourists were found to wear more clothes and the females among them preferred to cover up to maintain pale skin, as is a tradition in most Asian cultures.

4.2. Media, Culture and Perceptions of Comfort

The strong global media presence has been a driving force in carving out a climate perception and a critical link that cuts across established communities of scientists, policy, and civil society. Public discourses on current challenges are framed and shaped by media messages. People across diverse cultural backgrounds form their opinions based on media representations to interpret and make sense of climate science and government policies [43]. The cultural politics of climate change are being promoted in line with political and commercial interests. These are dynamic and contested processes, operating at multiple scales of climate science, policy, and politics that shape how meaning is grasped and negotiated.

4.3. Comfort, Culture, and Urban Design

A significant number of studies have favoured future urban design and planning projects incorporating careful climate-sensitive planning [2,12,44]. The physical components of a place and the strong relationship between microclimate and comfort conditions can help designers [16] address the site-specific microclimate and people's attendance, perceptions, and emotions concerning their surroundings. As already indicated, studies [25,29,30,32] have recommended that urban landscape and design should focus on climate sensitivity [28,29]. Architects should use their knowledge to consider thermal expectations, thermal history, and individual characteristics [32].

Cities as hubs of activity attract more attention now than ever before. With growing urbanisation, the emphasis is on a creative approach to microclimatic design to make cities liveable under changing climates and extreme weather events. Professionals in everyday practice implement climate-responsive design because of a lack of sufficient knowledge of the related field [2,5]. The OTC concept has always been of primary concern to scientists to make people comfortable in urban places. Urban microclimate as a topic of investigation and research has attracted scientific attention as it has come to influence or be influenced by a wide range of weather and human factors. This dynamic trend has driven researchers to constantly adapt to the evolving urban conditions and seasonal climate changes [44].

Architecture and anthropology are treating microclimates, as a new field, as artefacts. The intent is to show that a "meteorological survey" is no longer the purview of meteorology but has transcended it to accommodate cultural and social views. The adoption of the term "microclimate ethnography" suitably encompasses these cultural and social implications by seeking insights into urban ethnography to enrich the knowledge of urban thermodynamics. With climate change, approaches to urban microclimates as artefacts and cross-cultural subjects are emerging, as research begins to focus on cultural and social realms to address comfort [16]. Some studies have focused on local adaptation to the microclimate in changing urban conditions, while taking care of the social dimensions of urban living [5], by creating a favourable thermal environment as a precondition for human well-being. The above discussion may be assumed to be a modest yet significant step towards considering outdoor spaces, thermal climate indices, and climatic conditions when designing for future urban places.

5. Conclusions

Urban open spaces with comfortable biometeorological conditions appeal to citizens and boost a city's liveability. In thermal comfort research, less attention is paid to the cultural aspect of OTC. This study aimed to understand the relationship between people's

cultural backgrounds and their perceptions of weather conditions through a systematic literature review of recent studies.

The review study found that cultural background contributes to variations in thermal perceptions, tolerance to, and preference for certain thermal conditions, thermal comfort requirements and expectations, choice of clothing, and environmental attitudes. Hence, it can be concluded that individuals with diverse cultural backgrounds develop different levels of tolerance and comfort perceptions. A person's previous exposure to environment can determine differences in thermal perception through various habitual, technological, and psychophysiological adaptations. Furthermore, the study showed that applying theoretical models to OTC studies is limited, highlighting the need to explore the benefits of using theoretical frameworks to better explain the interplay between culture and OTC in this research field.

The current study adds value to the practical world and for end-users of outdoor spaces by providing a clear picture of individuals' thermal comfort needs in the creation of outdoor spaces. The current study can serve as a basis for future studies to validate these findings in other countries and contexts with different socio-cultural backgrounds. The future of thermal comfort OTC research lies in assessing the biometeorological characteristics of outdoor spaces and the meaning of comfort for those who use them. This, in turn, can help determine factors of sustainable thermal sensitive urban design. Utilising individuals' cultural backgrounds in approaching the comfort of outdoor spaces may help us better design outdoor settings. In a world with increasing uncertainty related to climate, the application of innovative research and design can provide a way to improve our understanding and management of urban environments. A more focused approach towards research about culture and urban climate can be made through enquiries about:

1. The relationship of the spatial dimension of comfort with culture and climate,
2. A cross-cultural analysis to determine how people perceive climate change at both local and global scales,
3. The socioeconomic and cultural responses to thermal comfort in urban environments.

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